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SUBSTRATE LAMINATING METHOD AND LAMINATING DEVICE

[Abstract]

PROBLEM TO BE SOLVED: To provide a substrate laminating method and a laminating device by which two substrates can be accurately and reliably laminate together in a short time, even in a large substrate.

SOLUTION: When two substrates are laminated together with mechanical pressurizing force in a vacuum chamber, pressurization mechanisms which pressurize the vicinities of four corner parts of the square substrates are

respectively provided, the gap between the substrates is observed after pressurizing the vicinities with the predetermined pressurizing force, and the vicinities are pressurized after adjusting the pressurizing force of each pressurization mechanism based on the observation. Thus, the laminating device which can make the gap between the substrates after lamination almost uniform is realized.

[Claims]

[Claim 1]

A substrate laminating apparatus in which an adhesive is coated on at least one of two sheets of substrates to be adhered, where one substrate is aligned with another substrate within a chamber of a decompression state, and the another substrate is mechanically pressurized against the one substrate, comprising:

first to fourth pressurization devices independently disposed at four edge portions of the substrate, for performing pressurization;

a fifth pressurization unit that performs main pressurization; and

a controller that drives the first to fourth pressurization devices and variably controls pressurization of the first to fourth pressurization devices according to an laminating condition of the substrates.

[Claim 2]

A substrate laminating apparatus including a support table supporting one of two sheets of substrates to be adhered within a chamber of a decompression state, a pressurization plate having an adsorption unit that adsorbs the other of the substrates, a pressurization unit that pressurizes the other of the substrates to the one of the substrates with the pressurization plate therebetween, and a positioning unit that positions a location of the two sheets of the substrates,

wherein the pressurization unit includes first to fourth pressurization devices which are disposed around four edge portions of the substrates and performs independent pressurization, the substrate laminating apparatus further includes a controller that drives the first to fourth pressurization devices up to predetermined pressure power, monitors an laminating condition, and variably

controls pressurization of the four pressurization unit according to the laminating condition.

[Claim 3]

The substrate laminating apparatus as claimed in Claim 1 or 2, wherein the adsorption unit provided in the pressurization plate includes a suction adsorption device that performs suction adsorption, and two adsorption units of an electrostatic adsorption device that performs adsorption through static electricity,

wherein the suction adsorption device is driven until the ambient changes from an atmospheric state to a vacuum state and laminating by mechanical pressurization is finished, and the electrostatic adsorption device is driven from a predetermined decompression state until laminating by mechanical pressurization is finished.

[Claim 4]

The substrate laminating apparatus as claimed in any one of Claims 1 to 3, wherein after mechanical pressurization is finished within the chamber of the decompression state, second pressurization is performed by applying atmospheric pressure to the substrates, thus making a distance between the substrates to be a certain distance.

[Claim 5]

A substrate laminating method in which at least one of two sheets of substrates is surrounded with an adhesive within a decompressed chamber, with liquid crystal dropped on a portion corresponding to a seal plane surrounded by the adhesive, the substrates being fixed to a table using a suction adsorption device having the table in a state where the liquid crystal dropped surface of one of the substrates on which the liquid crystal is dropped, the other of the

substrates being fixed to a pressurization plate through suction and adsorption, the inside of the chamber being decompressed and becomes a certain decompression state, an electrostatic adsorption device being driven to adsorb the other of the substrates against the pressurization plate, positioning with a lower substrate is performed in this state, after the positioning is finished, five pressurization units that pressurize the center of the pressurization plate and the four edge portions are driven to perform pressurization laminating, a distance between the substrates is monitored, and the distance between the substrates becomes uniform by variably pressurizing the pressurization units provided around the four edge portions according to the distance between the substrates.

[Claim 6]

A substrate laminating method in which a circular adhesive is coated on one of sheets of substrates within a vacuum chamber, with liquid crystal dropped within a circular plane, the substrate is fixed on a table with the liquid crystal surface being on top, the other of the substrates is adsorbed to a pressurization plate and is positioned with a lower substrate, pressurization laminating is performed on the upper substrate and the lower substrate using pressurization units provided at the center of the pressurization plate, after laminating is finished through predetermined pressurization, a distance between the adhered substrates is measured, and four pressurization units that pressurize four edge portions of the pressurization plate are independently driven according to the measurement results, thus making the distance between the substrates almost uniform.

[Claim 7]

A substrate laminating method in which at least one of two sheets of substrates is surrounded with an adhesive within a decompressed chamber, with liquid crystal dropped on a portion corresponding to a seal plane surrounded by the adhesive, the substrates are fixed to a table using a suction adsorption device having the table in a state where the liquid crystal dropped surface of one of the substrates, on which the liquid crystal is dropped, the other of the substrates is fixed to a pressurization plate through suction and adsorption, the inside of the chamber is decompressed and becomes a predetermined decompression state, an electrostatic adsorption device is driven to adsorb the other of the substrates against the pressurization plate, positioning with a lower substrate is performed in this state, after the positioning is finished, five pressurization units that pressurize the center of the pressurization plate and the four edge portions are driven to perform pressurization laminating, the inside of the chamber returns to the atmospheric pressure, a compression state of the seal between the substrates is monitored, and the amount of the seal between the substrates becomes uniform by variably pressurizing the pressurization units provided around the four edge portions according to the compression state of the seal.

[Claim 8]

A substrate laminating method in which a circular adhesive is coated on one of sheets of substrates within a vacuum chamber, having liquid crystal dropped within the circular plane, the substrate is fixed on a table with the liquid crystal surface being top, the other of the substrates is adsorbed to a pressurization plate and is positioned with a lower substrate, pressurization laminating is performed on the upper substrate and the lower substrate using pressurization units provided at the center of the pressurization plate, after

laminating is finished using certain pressurization, the ambient state returns to atmospheric pressure state, a compression state of the seal between the adhered substrates is monitored, and four pressurization units that pressurize four edge portions of the pressurization plate are independently driven according to the monitoring results, thus making the amount of the seal between the substrates almost uniform.

[Title of the invention]

SUBSTRATE LAMINATING METHOD AND LAMINATING DEVICE

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a substrate laminating method and apparatus thereof in which liquid crystal display panels, etc. are adhered under vacuum.

[0002]

[Description of the Prior Art]

A process of manufacturing liquid crystal panels includes a process of adhering adhesives (hereinafter, referred to as "sealant") so that a distance between two sheets of glass substrates having a transparent electrode, a thin film transistor array, etc., becomes about 2 μm in order to form a space in which liquid crystal is sealed between the two substrates.

[0003]

For example, Japanese Unexamined Patent Application Publication No. 2001-51284 discloses an laminating apparatus. The apparatus includes a first pressurization device that applies pressurization to both the substrates when positioning an laminating location between a lower substrate and an upper substrate, and causes a bottom surface of the upper substrate to be in contact with an adhesive on a surface of the lower substrate, and a second pressurization device that adheres the upper substrate to the lower substrate using the adhesive and applies other pressurization different from the first pressurization device until a distance between both the substrates becomes a predetermined distance.

In this case, the first pressurization device and the second pressurization device are driven at different timings.

[0004]

If the size of substrates to be adhered together is great, however, it is difficult to uniformly pressurize the whole substrates by means of a conventional pressurization unit. Thus, it is necessary to perform laminating by controlling pressurization while viewing a pressurization state of each end of the substrates.

[0005]

An object of the present invention is to provide a substrate laminating method and apparatus thereof, in which two sheets of substrates can be adhered with good accuracy and in a sure way within a short time even in the case of a great substrate.

[0006]

[Means for Solving the Problem]

In order to accomplish the above object, according to the present invention, a pressurization unit that pressurizes the central portion of a substrate, and pressurization units that pressurizes four edge portions of almost a square substrate are provided within a vacuum chamber as a pressurization unit that applies pressurization. After predetermined pressurization is applied using the pressurization unit that pressurizes the central portion and the pressurization units that pressurize the four edges portions, a distance between the substrates or a compression state of an adhesive is monitored. The pressurization units that pressurize the four the edge portions are individually controlled according to the monitoring results, so that the distance between the substrates become equal.

[0007]

[Embodiment of the Invention]

A substrate laminating apparatus of the present invention will be described in detail in connection with an embodiment with reference to Figs. 1 and 2. Fig. 1 is a schematic lateral view showing the construction of a substrate laminating apparatus according to the present invention. Fig. 2 is a surface view of the substrate laminating apparatus shown in Fig. 1.

[0008]

<Construction of Substrate Laminating Apparatus of Present Invention> The substrate laminating apparatus of the present invention includes a stage unit S1, a substrate junction unit S2, and a Z-axis direction motion stage unit S3 having a pressurization unit, as shown in Fig. 1. On the mounting plate 1 are disposed a frame 2 that supports the substrate junction unit S2 and a frame 3 that supports the Z-axis direction motion stage unit S3. The stage unit S1 is disposed on a top surface of the mounting plate 1. Further, a controller (not shown) that controls each unit, the pressurization unit, etc. is provided in the substrate laminating apparatus of the present embodiment.

[0009]

An X stage 4a having a driving motor 5 is disposed in the stage unit S1. The driving motor 5 moves the Y stage 4b disposed on the X stage 4a in the X-axis direction of Fig. 1. Furthermore, the Y stage 4b has a driving motor 6. The driving motor 6 moves a θ stage 4c on the Y stage 4b in a Y-axis direction orthogonal to the X axis and Y axis of Fig. 1. Further, on the θ stage 4c having the driving motor 8 is disposed a support body 10a supporting a support pole 10.

The driving motor 8 moves the support body 10a against the Y stage 4b via a rotary bearing 7.

[0010]

A table 9 on which a lower substrate is mounted is disposed on the support pole 10. Further, the bottom of the vacuum bellows 12 is fixed to the θ stage 4c via an arm 11. In addition, in order to secure good rotation and tightness of the support pole 10, a rotary bearing 13 and a seal 14 are fixed to the support pole 10 by means of the arm 11. When the support pole 10 rotates, the arm 11 and the vacuum bellows 12 are constructed not to rotate together with the support pole 10.

[0011]

Furthermore, the substrate junction unit S2 includes a chamber 15, the table 9 and a pressurization plate 16 disposed within the chamber 15, a substrate container ring 40 that supports a upper substrate 34, which is separated from the pressurization plate 16 when the inside of the chamber 15 is decompressed, which will be described later, and a gate valve 17 disposed at the inlet port of the chamber 15. The table 9 is fixed on the stage unit S1 via the support pole 10, as described above.

[0012]

Furthermore, the pressurization plate 16 is fixed to a central guide plate 29 of the Z-axis direction motion stage unit S3 via a plurality of the support poles 27. Moreover, the circumference of each of the support poles 27 is surrounded by a bellows 28 having one end fixed to the chamber 15 and the other end fixed to the central guide plate 29, and is constructed to maintain a decompression state within the chamber 15 upon laminating of substrates. In addition, in the present

embodiment, the pressurization plate 16 is fixed to the central guide plate 29 with the five support poles 27 therebetweeen.

[0013]

Pipes 20a and 20b for decompressing and exhausting the inside of the chamber 15 are disposed to an inner bottom of the chamber 15. The pipes 20a and 20b are connected to a vacuum pump with a switch valve (not shown) therebetweeen. Furthermore, the pressure within the chamber 15 when adhering the substrates together is about 5×10^{-3}Torr.

[0014]

Moreover, a plurality of windows to which the atmosphere is precluded in order to monitor positional matching marks of substrates to be adhered together is disposed on an upper side of the chamber 15. The recognition camera 26 is used to measure deviation of marks for positioning upper and lower substrates through a mark recognition hole (not shown), which is disposed in the pressurization plate 16, from the windows.

[0015]

An electrostatic adsorption device having an electrostatic adsorption electrode for adsorbing substrates and a suction adsorption device having a plurality of suction adsorption holes are disposed in the table 9. Each of the adsorption holes is connected to the vacuum pump via an adsorption valve (not shown), which is disposed outside the chamber 15 with the pipe 18 therebetween. Further, a bypass pipe for opening to the atmosphere via a valve for breaking vacuum is disposed in the middle of the pipe 18. By opening the valve for breaking vacuum, it is possible to forcedly release an adsorption state.

[0016]

Furthermore, a plurality of elevation pins 35 for raising the lower substrate 33 received from a moving machine (not shown) over the table 9, or taking out the substrate after laminating (hereinafter, a substrate after laminating is referred to as "cell") is disposed in the table 9. The elevation pins 35 can move the hole provided in the table 9 in the Z-axis direction. This movement is performed by the cylinder 36.

[0017]

Meanwhile, an electrostatic adsorption device having an electrostatic adsorption electrode and a suction adsorption device having a plurality of adsorption holes for decompression are disposed in the pressurization plate 16 in the same manner as the table 9. Each of the suction adsorption holes is coupled to the vacuum pump via an adsorption valve (not shown) disposed outside the vacuum chamber 15 with the pipe 19 therebetween.

[0018]

In this case, in the present embodiment, four pressurization units 41 to 44 are disposed over the central guide plate 29 in such a manner that they are projected upwardly from the central guide plate 29 (upwardly from the support poles 27). Further, one pressurization unit 45 is disposed almost at the central portion of the plane. In addition, a linear guide that can move the up and down directions against the frame 3 is disposed in the central guide plate 29. A driving unit of each of the pressurization units 41 to 45 is fixed to fixing support members 46a, 46b, 46c, 46d and 47 disposed in the frame 3.

[0019]

A driving unit of the pressurization unit includes motors 41a, 42a, 43a, 44a and 45a to which an encoder is attached, and ball screws 41b, 42b, 43b, 44b and

45b. Furthermore, load cells 41c, 42c, 43c, 44c and 45c are disposed at locations where force is applied to the central guide plate 29 of each of the ball screws.

[0020]

Furthermore, a linear guide 30 that moves in the Z-axis direction is disposed in a supplement member 48 that applies force to the central guide plate 29 or the central guide plate 29. The linear guide 30 is adapted to move along the rail disposed in the frame 3. By driving the pressurization unit to move the central guide plate 29 downwardly, the pressurization plate 16 fixed to the support poles 27 is depressed downwardly and the upper substrate 34 adsorbed to the pressurization plate 16 is pressurized and compressed to the lower substrate 33.

[0021]

Further, the present embodiment adopts a construction in which five pressurization units are disposed. However, the present embodiment can be applied to a construction in which force is equally applied around four edges of a square substrate, i.e., a construction in which four pressurization units are disposed. Further, the present embodiment adopts a construction in which force is applied to the pressurization plate 16 via the central guide plate 29. However, the pressurization unit can be constructed such that force is directly applied to the pressurization plate 16.

[0022]

An operation of adhering substrates for a liquid crystal panel using substrate laminating apparatus constructed above will be below described.

[0023]

When adhering substrates for a liquid crystal panel, an adhesive is previously once coated so that it is not disconnected in such a manner that a circumference is formed at one side of the upper substrate 34 or the lower substrate 33, which are used to adhere the substrates. Fig. 6 shows an example of the circumference formed. Further, a substrate on which the adhesive is coated is used as a lower substrate, and a small amount of liquid crystal is dropped within the circumference of the adhesive. In this case, before the liquid crystal drops or before adhering the substrates after the liquid crystal drops, spacers for defining a distance between the substrates are distributed in the lower substrate or the upper substrate. Moreover, the spacers can be mixed in liquid crystal. In addition, in the present embodiment, it has been described that the adhesive is coated on the lower substrate 33. However, the adhesive can be coated on the upper substrate 34. In this case, the liquid crystal drop region on the part of the lower substrate need to be included in a region surrounded by an adhesive provided in the upper substrate.

[0024]

As such, after the adhesive is coated on one of the substrates, the substrate laminating apparatus performs the laminating operation. The laminating process will be below described.

[0025]

Firstly, the film plane of the upper substrate 34 is laid on a moving machine (not shown) disposed outside the chamber 15. The outer circumference of the upper substrate 34 is adsorbed to the hand form a lower side. The gate valve 17 at the entrance of the chamber 15 is opened, and the hand of the moving machine is inserted into the chamber. The pressurization plate 16 is pressed against the

upper substrate 34, and the upper substrate 34 is sucked upwardly through vacuum absorption using the suction adsorption holes of the suction adsorption device provided in the pressurization plate 16. Thus, the upper substrate 34 is absorbed to the pressurization plate 16. As such, after the substrate 34 is absorbed to the pressurization plate 16, suction adsorption of the upper substrate 34 in the hand of the moving machine is stopped. The hand is then removed out of the chamber 15. Further, in the present embodiment, it has been described that the hand of the moving machine has a suction adsorption function. The moving machine can be just inserted into chamber by grasping the upper substrate using the ring unit.

[0026]

The front end of the elevation pins 35 disposed in the table 9 within the chamber 15 is raised such that it is projected from a surface of the table 9. At the same time, after the lower substrate 33 is supported by the hand of the moving machine with a plane on which liquid crystal is dropped in the lower substrate 33 being top, the lower substrate 33 is inserted into the chamber 15, and the lower substrate 33 is moved on the elevation pins 35 that is raised above. After the movement, the hand of the moving machine is removed out of the chamber 15, the gate valve 17 is closed, and the elevation pins 35 is further lowered, so that the lower substrate 33 can be moved on the table 9. After the lower substrate 33 is moved on the table 9, the suction adsorption hole of the table 9 is driven to vacuum-absorb the lower substrate 33 against the table 9.

[0027]

As described above, if both the substrates 33 and 34 are fixed to the table 9 and the pressurization plate 16, respectively, by way of suction adsorption, the

valve on the part of the exhaust pipe 20a having a small diameter is opened to slowly exhaust a gas within the chamber 15. In this case, the exhaust speed upon exhaust is set to the extent that the substrates are not severely moved by the flow of the gas, the liquid crystal on the lower substrate 33 does not scatter, and moisture is not frozen by means of decompression. When the exhaust of the chamber 15 is slowly executed and the exhaust speed becomes a pressure where the substrates are not severely moved, the liquid crystal does not scatter, and moisture is not frozen if the speed increases (e.g., the upper substrate 34 absorbed by means of vacuum adsorption force is decompressed to the extent that it is not separated from the pressurization plate 16), the valve of the pipe 20a is shut, and the valve of the pipe 20b is opened, whereby the inside of the chamber is rapidly decompressed up to a pressure (5×10^{-3}Torr) in which the upper and lower substrates are adhered together.

[0028]

In this case, if the inside of the chamber 15 is decompressed as above, the atmospheric pressure of the vacuum room is lower than the adsorption force of the upper substrate 33. Accordingly, there is a case where the upper substrate 34 is frequently separated from the pressurization plate 16. For this reason, a substrate container ring 40 is disposed on the part of the pressurization plate 16 within the chamber 15. In the case where the atmospheric pressure within the chamber 15 is lowered and the upper substrate34 is thus fallen from the pressurization plate 16, the upper substrate 34 is supported by the substrate container ring 40. Furthermore, the substrate container ring 40 is moved (shunts) so that it is not latched to the cross section of the substrates when the substrates

are adsorbed or mechanically pressurized (being depressurized by the pressurization plate 16).

[0029]

As described above, the process of adhering both the substrates 33 and 34 fixed to the table 9 and the pressurization plate 16 will be described in detail with reference to Fig. 3. Fig. 3 is a view showing a timing chart of operations of decompression condition within the chamber, the action of suction power and driving situation positional decision of the motor until the inside of the chamber is opened to the atmosphere after the substrates are supported, pressurized and adhered together.

[0030]

As shown in Fig. 3, after the upper substrate 34 is absorbed to the pressurization plate 16 by way of suction adsorption at a point t1, the lower substrate 33 moves the table 9 within the chamber 15 and is adsorbed on the table 9. At a point t2, the inside of the chamber is decompressed. In this case, at a time t3 during the decompression process, the pressure within the chamber become slower than suction adsorption force applied to the upper substrate 34 that has been supported to the pressurization plate 16 by way of suction adsorption. Thus, there is a case where the upper substrate 34 falls on the substrate container ring 40 without being adsorbed thereto. At this time, at a time t4 of a predetermined decompression state, the upper substrate 34 is electrified to an electrode that performs electrostatic adsorption, and the upper substrate 34 is absorbed to the pressurization plate 16 again. Further, the term "predetermined decompression state" refers to a state where discharge is not generated between electrodes on an electrostatic adsorption plate.

[0031]

At this time, the reason why suction adsorption and electrostatic adsorption are used jointly as in the above in the present embodiment will be below described. In order to make the upper substrate 34 absorbed to the pressurization plate 16 only with vacuum adsorption, it is necessary to suck the upper substrate 34 with adsorption force greater than decompression force that decompresses the inside of the chamber 15. This necessitates the use of a vacuum pump having a greater volume. Furthermore, if the pressurization plate 16 of the upper substrate 34 is decompressed after electrostatic adsorption is performed in the atmosphere, air remaining between the upper substrate 34 and the pressurization plate 16 expands and exits. Thus, a gap is partially creased between the upper substrate 34 and the pressurization plate 16. A discharge phenomenon is also generated between negative and positive electrodes provided in the pressurization plate 16, thus damaging the upper substrate 34 or the pressurization plate 16. In addition, since electrostatic adsorption force is lowered due to discharge, the upper substrate 34 drops. At this time, there is a case where a discharge is further generated if the gap between the substrates becomes a predetermined size. The discharge under vacuum is generated in the relationship between a voltage and pressure and a gap between electrodes by Paschen's Law. Accordingly, if the upper substrate 34 is electrostatically adsorbed to the pressurization plate 16 in the atmosphere, air exits during decompression, inevitably resulting in this phenomenon.

[0032]

In the above, in the present embodiment, after vacuum is accomplished to the extent that a discharge phenomenon is not generated, electrostatic

adsorption is performed. It is thus possible to miniaturize the apparatus and also to adsorb both the substrates 33 and 34 to the pressurization plate 16 or the table 9 plane in a sure and complete manner. Further, in the timing chart shown in Fig. 3, before the completion of decompression, electrostatic adsorption is performed by applying a voltage to an electrostatic adsorption electrode between the table 9 and the pressurization plate 16. However, electrostatic adsorption can be performed after decompression is completed.

[0033]

As described above, after both the substrates 33 and 34 are fixed to the table 9 and the pressurization plate 16 by way of suction adsorption, the pressurization plate 16 is adjust to be parallel to the table 9. Thereafter, in order to lower the central guide plate 29 of the Z-axis direction motion stage unit S3, the motors of the pressurization units are cooperatively driven to make the upper substrate 34 approach the lower substrate 33. Before the upper substrate 34 is in contact with the adhesive provided in the lower substrate 34, the recognition camera 26 detects positional matching marks attached to the upper and substrate, and measures positional deviation between the substrates. The table 9 in which the lower substrate 33 is located drives the stage S1 based on the measurement, and positions the lower substrate 33 in the upper substrate 34.

[0034]

After positioning, the central guide plate 29 is further lowered to compress the adhesive coated on the lower substrate 33. In a state where liquid crystal is sealed within the circumference formed by the adhesive, first laminating is performed. Furthermore, during first laminating, a positioning work is performed using the camera immediately after the upper substrate 34 is in contact with the

adhesive. This positioning work is repeated several times until application of highest pressurization is finished. The reason why positioning is repeated several times as such is as follows. Although pressurization is uniformly applied, the compression degree of the adhesive is not uniform and the action of force in the adhesive portion is generated in the irregular portion because the adhesive is not uniformly coated. Accordingly, shear force is generated between the upper and lower substrates, leading to deviation between the substrates.

[0035]

After first laminating, the application of a voltage to the electrostatic adsorption electrode of the pressurization plate 16 is stopped, and suction adsorption is also stopped. Further, the pressurization unit is driven to raise the pressurization plate 16. Thereafter, a gas is injected into the chamber 15, returning the atmospheric pressure within the chamber 15 to the atmospheric pressure.

[0036]

In this case, upon laminating, it is difficult to make the pressurization plate 16 exactly parallel to the surface of the table 9. Thus, the adhesive is irregularly compressed upon laminating, or the adhesive is irregularly compressed due to deformation of the substrate itself, etc., thus making irregular a distance between the substrates after laminating. Due to this, before the pressurization plate 16 is raised as in the above, the compression amount of the adhesive at each side of the substrate is monitored. With respect to the side having a low compression amount, the compression amount of the adhesive is made uniform by increasing pressurization of a pressurization unit having a low compression amount and lowering pressurization of a pressurization unit having a high compression

amount, among the pressurization units disposed in the periphery (four edge portions).

[0037]

Furthermore, in the present embodiment, it has been described that the compression amount of the adhesive is monitored within the decompressed chamber 15. However, the compression amount of the adhesive is monitored after the inside of the chamber 15 returns to the atmospheric pressure. Further, pressurization of each of the pressurization units can be set so that several substrates can be adhered and the compression amount of each of units of an adhesive becomes regular.

[0038]

Hereinafter, the operation of making uniform the compression amount of each of units of an adhesive will be described with reference to Figs. 4 and 5. Fig. 4 is an example in which the adhesive 37 is unbalancely compressed. Fig. 5 is a view showing a method of controlling a gap in the state of Fig. 4.

[0039]

As shown in Fig. 4, if the compression amount of the adhesive 37 on the left side of the drawing is high and the compression amount of the adhesive 37 on the right side of the drawing is low, the pressurization unit operates in an arrow direction by reducing pressurization of the pressurization units 41 and 42 and increasing pressurization of the pressurization units 43 and 44, as shown in Fig. 5. Furthermore, the central portion keeps intact. It is thus possible to solve irregularity of a gap between substrates, which is incurred by deformation of substrates or an irregular coating amount of the adhesive 37. Furthermore, in the present embodiment, in order to pressurize the periphery of the substrates

independently, the pressurization units can be constructed to independently operate. Further, the method of monitoring the compression amount of the adhesive 37 can be viewed by the eye. A method of measuring the compression amount of the adhesive 37 using an optical system such as a camera, a method of detecting the compression amount of the adhesive 37 using a gap sensor, and the like can be employed.

[0040]

In this case, in the case where the size of a panel is small, desired pressurization can be applied using a mechanical pressurization unit, as described above. If the size of a panel is great, however, it is necessary to increase the size of a pressurization device itself and also to apply high pressurization in order to secure a predetermined between substrates using mechanical pressurization. In order to maintain the size of an apparatus to a current state, other pressurization means can be considered. However, if the pressure changes from the vacuum state to the atmospheric pressure, higher pressure can be applied to the entire substrates since the inside of the substrate is a vacuum state. For example, in case of two sheets of substrates having the size of 1200 mm×1000 mm, when the inside of the substrate is in the vacuum state, force of 121.6 kN can be exerted by adding the atmospheric pressure.

[0041]

A gap between substrates when the highest pressurization is mechanically applied by the pressurization plate 16 using an apparatus of a current state is about 15 μm, an laminating sate is incomplete. That is, since a desired gap is not accomplished in a first pressurization (preliminary pressurization) state, the compression amount of an adhesive is few and the length of a contact portion

between upper and substrates of the adhesive is short. Furthermore, since liquid crystal sealed within a cell does not diffuse into the cell, a great vacuum space unit is formed between the liquid crystal. Accordingly, higher pressurization is needed to make the gap below 5 μm (preferably 4 μm or less) between the substrates.

[0042]

In performing secondary pressurization on the substrates (pressurization by returning the inside of the chamber to the atmospheric pressure: second pressurization), it is possible to almost uniformly apply pressure to the entire plane of the substrate by returning the circumference to the atmospheric pressure because the inside of a cell between the substrates is close to the vacuum state. If the circumference returns to the atmospheric pressure at once, however, a gas tears the adhesive 37 and enters the vacuum space unit within the cell since the adhesive 37 is not yet sufficiently compressed. This results in a defective product as a liquid crystal substrate. Due to this, in the present embodiment, after pressurization by the pressurization plate 16 is finished, the pressurization plate 16 is separated from the plane of the substrate. The valve 22 of the pipe 21 is opened and the circumference slowly returns to the atmospheric pressure by introducing a gas pressurized in the pressure source into the chamber 15. At the same time, by introducing the atmosphere (or nitrogen gas, etc.) into the chamber 15 using the suction adsorption hole, distribution of the gas within the chamber 15 can be made uniform. As such, if the inside of the chamber 15 slowly returns to the atmospheric pressure, pressure is slowly applied to the cell, and the adhesive 37 is slowly compressed. As a difference between the pressure in the space of vacuum within the cell and the pressure

within the chamber 15 slowly increases, an introduced gas does not tear the adhesive and does not enter the cell. Further, a contact area between the adhesive and the upper and substrate slowly expands.

[0043]

Furthermore, when the gap between the substrates becomes about 10 μm, the adhesive 37 is compressed to cause fluctuation, and has a lowered viscosity due to a thixotropy property. In a state where the viscosity of the adhesive 37 is lowered, high pressurization is applied to the substrates by opening the atmospheric open valve 23 that abruptly makes the atmospheric pressure. At this time, since the adhesive already diffuses against the substrate and a sealing property is improved, there is no possibility that a gas may tear an adhesive and may enter a cell. Further, as the adhesive has a lowered viscosity, it is rapidly compressed, and the compression of the adhesive diffuses since liquid crystal is also pressurized. An laminating time of the substrates becomes also short. In addition, the atmospheric open valve 23 is opened after confirming that the pressure gauge provided in the chamber 15 exceeds a predetermined pressure.

[0044]

As described above, the laminating operation in the present embodiment is carried out. Further, in the process of the present embodiment, the pressurization unit that pressurizes the central portion of the pressurization plate and the four pressurization units that pressurize the periphery of the pressurization plate are driven at the same time upon pressurization. Pressurization is first performed using the central pressurization unit without using the five pressurization unit at the same. In order to solve the irregularity in compression of an adhesive due to he irregularity of pressurization applied to the

substrates or the irregularity in the amount of the adhesive, a compression state of the adhesive is monitored, and the pressurization units is individually driven based on the monitoring results, making regular the compression amount of the adhesive.

[0045]

Furthermore, pressurization units that pressurize edge portions (four edges) of a square substrate are disposed without providing the center pressurization unit, and the four pressurization units are cooperatively controlled to apply pressurization. After pressurization is applied, the compression amount of an adhesive is monitored and the four pressurization units are then independently driven according to the compression amount. It is thus possible to make uniform the compression amount of the adhesive.

[0046]

Hereinafter, another embodiment of the present invention will be described. Fig. 7 is a lateral view of another embodiment of the present invention. Fig. 7(a) is a partial lateral view and Fig. 7(b) is a view when there is unbalance of compression in another embodiment.

[0047]

The present embodiment is different from the aforementioned embodiment in that when the central guide plate 29 is depressed and lowered by the central pressurization unit 45, the four pressurization units provide in the periphery of the substrates move downwardly together with the central guide plate 29. That is, the four pressurization units 41 to 44 are fixed to a pressurization unit guide member 55 such that they move together with the central guide plate 29. Further, in the case where force is applied to the central guide plate 29 from the four

pressurization units, a distance between the pressurization unit guide member 55 and the central guide plate 29 can vary by driving each ball screw. As such, since the operation of the four pressurization units is separately performed from the operation of the central pressurization unit, control is easy and work time can be shortened.

[0048]

Furthermore, a liquid crystal substrate according to the present embodiment is multi-planed in a large-scale substrate. For this reason, a dummy seal 39 to surround the entire seal portion 37 constituting a plurality of liquid crystal substrates is provided in the substrate used in the present embodiment, as shown in Fig. 6. The entire plane constructed of a dummy seal of a substrate has uniform pressure distribution due to the action of a vacuum state between the seal portion constituting the liquid crystal substrate and the dummy seal unit. It is thus possible to form a liquid crystal panel having a good substrate distance by using the present apparatus.

[0049]

[Effect of the Invention]

As described above, in accordance with an laminating apparatus and method thereof according to the present invention, two sheets of substrates (more particularly, a liquid crystal substrate) can be adhered with good accuracy within a short time in sure, preferable and safe ways.

[Description of Drawings]

Fig. 1 is a front view showing a substrate laminating apparatus of the present invention.

Fig. 2 is a view of Fig. 1 when viewed from the top.

Fig. 3 is a view showing a timing chart of the operation of units when performing laminating under vacuum.

Fig. 4 is a view when there is unbalance of compression of a seal between substrates when applying mechanical pressurization under vacuum.

Fig. 5 is a view showing a control method when unbalance of Fig. 4is generated.

Fig. 6 is a view showing an example of a coating shape of a seal member when an laminating apparatus of the present invention is used.

Fig. 7 is a lateral view of another embodiment of the present invention, Fig. 7(a) is a partial lateral view, and Fig. 7(b) is a view when there is unbalance of compression in another embodiment.

[Explanation on Numerals]

9: Table

15: Chamber

16: Pressurization plate

20a: Pipe

20b: Pipe

22: Valve that slowly returns atmospheric pressure

23: Standby open valve

33: Lower substrate

34: Upper substrate

37: Adhesive

40: Substrate container ring

41 to 45: Pressurization unit